These four theses, which were equally defended by Patrizi, Campanella, and others, provide the background to Newton's ontology of space as it is sketched in the *De gravitatione*.[42] They were also endorsed by Leibniz when he began his philosophical career; I offer here an outline of these early views on space.

The first extant reference by Leibniz to space is found in his *marginalia* on Daniel Stahl's *Compendium metaphysicum*. These notes were probably taken by Leibniz in 1663, when he was seventeen and a student in Jena. In the *Compendium*, Stahl voiced the Scholastic opinion that mathematics does not attain the substance of things, since it deals with quantities and figures, which are mere accidents of matter. To this, Leibniz remarked:

> On the contrary, mathematics deals with substance more than physics does, since space is the first extended thing.[43]

Leibniz's earliest statement on space argued for its substantiality and stressed its connection with geometry.

In the next few years, Leibniz claimed that the definition and essence of body is *to exist in space*: space is therefore the condition of bodies. It may exist without them, and Leibniz argued in fact for the existence of a vacuum. The motion of a body consists in the change of space (*mutatio spatii*) and is therefore absolute rather than referred to other bodies.[44] The first principles

[42] On space as neither substance nor accident but an emanative effect of God, see A. R. Hall and M. Boas Hall (eds.), *Unpublished Scientific Papers of Isaac Newton* [*Newton*] (Cambridge: Cambridge University Press, 1962), 99; on resistance, see 106–7; on extension, quantity, and primary matter, see 98 and 107; on space and geometrical figures, see 100.

[43] Daniel Stahl had been a professor, dean, and rector in Jena, and it is likely that Leibniz acquired and read the book when he was a student there in the summer semester of 1663. See D. Stahl, *Compendium metaphysicae in XXIV. tabellas redactum* (Jena: Sengenwald, 1655): 'Cùm Scientia Mathematica ex adversó in quantitate et figuris, qua accidentia sunt, versentur, et substantia rationem non attingant, teste Aristotele *XII. Metaphys.*' (31). To which Leibniz objected with the quoted sentence (A VI, 1, N. 2, 31). This position may already represent an evolution from Leibniz's thesis in the *Disputatio metaphysica de principio individui* (written earlier that year), in which matter (rather than space) and quantity were (tentatively) identified: 'Non omnino improbabile est materiam et quantitatem esse realiter idem' (A VI, 1, N. 1, 19). Consistent with Leibniz's remarks on Stahl is a passage in the celebrated *Dissertatio de arte combinatoria* (1666), in which Leibniz states that geometry deals with the quantity of bodies or the quantity of space, which is 'coextended to bodies': 'Nam uti Arithmetica atque Analysis agunt de Quantitate Entium; ita Geometria de Quantitate corporum, aut spatii quod corporibus coextensum est' (A VI, 1, N. 8, 171; cf. also the critical edition with English translation: M. Mugnai, H. van Ruler, and M. Wilson (eds.), *G. W. Leibniz. Dissertation on Combinatorial Art* [*Combinatorial Art*] (Oxford: Oxford University Press, 2020), 72.

[44] See the *Confessio naturae contra atheistas*: 'Definitio autem corporis est spatio inexistere' (A VI, 1, N. 13, 490); 'Motus enim est mutatio spatii' (491); 'Corporis essentia est: esse in spatio, existentiae in spatio variatio est motus' (493). See also the contemporary *De*

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of mathematics (*prima principia matheseos*) are equated with an investigation of space (*de spatio*).[45]

A quite extensive treatment of the philosophy of space can be found in Leibniz's correspondence with Jakob Thomasius of 1668–9. One of Leibniz's explicit goals in this correspondence was to show his former teacher that Aristotle's philosophy (purged of its Scholastic corruptions) is compatible with the main tenets of modern metaphysics.[46] Although embellished with a thin layer of *tinctura Aristotelis*, Leibniz was expounding quite radical modern doctrines—including a Neoplatonic theory of space. Leibniz's main line of attack concerned the notion of substantial form, which he wanted to equate with the geometrical form (figure or shape) of bodily things. In this way he hoped to frame the modern geometrical and mechanical explanations of phenomena in an Aristotelian ontology. This was not an unprecedented move, and Aristotelians themselves had already noticed a remarkable analogy between form and figure.[47] Leibniz went well beyond these opinions by

Transsubstantiatione: 'Essentia seu definitio Corporis est esse in spatio. Variatio igitur essentiae corporis est variatio existentiae in spatio. Variatio existentiae in spatio, est motus' (A VI, 1, N. 15_2, 508). In a marginal note to the *Demonstrationum catholicarum conspectus* (which might have been added later, but probably belongs to the same period), Leibniz contrasts his own position with that of Aquinas, who took matter to be a nonbeing (rather than something space-filling), and quantity to be an accident: 'Quia materia sec. Thomam est non Ens, sec. nos ipsa moles, s. id quod implet spatium quod illi pro quantitate s. accidente habuerunt' (A VI, 1, N. 14, 497). Already in his student theses of 1664, Leibniz had stated that no one had disproven the existence of a vacuum: 'Vacuum non dari probatum firmiter nondum vidimus' (A VI, 1, N. 4, 95). See also Leibniz to Thomasius, 20/30 April 1669; A II, 1, N. 11, 25. A more affirmative claim on the existence of a vacuum is found in a further fragment of 1669 (A VI, 2, N. 38_1, 164).

[45] Again in the *Demonstrationum catholicarum conspectus*, in A VI, 1, N. 14, 494.

[46] Jakob Thomasius aimed to *reform* Aristotelian philosophy, but it is clear that by 'reformation' he intended a philosophical analog to Luther's endeavor, that is, a *restoration* of the old and true meaning of Aristotle's philosophy that had been corrupted by Scholasticism; cf. J. Thomasius, *Dissertationes LXIII ad Stoicae philosophiae et caeteram philosophicam historiam* (Halle: Günther, 1693), 441, where Descartes is seen as a failed reformer who invented a new heresy. On the Leibniz–Thomasius correspondence, see the edition and commentary by R. Bodéüs (ed.), *Leibniz–Thomasius. Correspondance 1663–1672* (Paris: Vrin, 1993); and C. Mercer, 'Leibniz and His Master: The Correspondence with Jakob Thomasius', in P. Lodge (ed.), *Leibniz and His Correspondents* (Cambridge: Cambridge University Press, 2004), 10–46. Leibniz's most important letter to Thomasius of 20/30 April 1669 was a treatise on its own and was published by Leibniz in his preface to the work of Nizolius in 1670 (now in A VI, 2, N. 54, 398–475).

[47] In the previous century, Fonseca had stated that a figure is the accident that best represents the substantial form (*figura maxime representat formam substantialem*). See *In metaphysicam*, V, VII, explanatio (vol. 2, 415). Toletus had expressed similar views, on which see Des Chene, *Physiologia*, 109–21. Dennis Des Chene offers the perspicuous analogy that, for many Schoolmen, figure was to quantity as form was to matter: and since matter and quantity were often identified or quasi-identified, the conclusion was obvious. As for Leibniz, his opinion is most clearly stated in his letter to Thomasius of 20/30 April 1669: 'Hoc unum in quaestione est, an quae Aristoteles de materia, forma, et mutatione abstracte disputaverit, ea explicanda

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not only identifying the two notions but connecting figure with *space*. This is a straightforward consequence of space being the substrate of geometry:

> Aristotle himself assumed that mathematical objects (τὰ μαθηματικά), i.e. space or its determination – figure – is a substance. His argument is that geometry is about these objects, and geometry is the most perfect science after metaphysics. The object of any science, according to Aristotle's doctrine, is indeed a substance. But then if a figure is something substantial, if it belongs to body, if it is truly distinct from matter, what else would it be if not a substantial form? Besides, space itself is almost more substantial than body.[48]

Needless to say, this was not Aristotle's view, and Thomasius protested against Leibniz's interpretation.[49] Leibniz replied by restating his views,[50] and pushed them yet further:

> primary matter is mass itself, in which there is nothing but extension and ἀντιτυπία, or impenetrability. Primary matter acquires extension from the

sint per magnitudinem, figuram, et motum. Id Scholastici negant, Reformatores affirmant. Reformatorum sententia mihi non solum verior, sed et Aristoteli magis consentanea videtur' (A II, 1, N. 11, 25–6). On Leibniz's involvement with these views, see M. Laerke, 'Form, Figure, and Two Types of Extended Being. Averroism in the Young Leibniz' ['Averroism'], in Donald Rutherford (ed.), *Oxford Studies in Early Modern Philosophy, Volume IX* (Oxford: Oxford University Press, 2019), 131–65.

[48] Leibniz to Thomasius, 26 September/6 October 1668, in A II, 1, N. 9, 18–19.

[49] According to Aristotle, τὰ μαθηματικά are abstractions that we may consider *as if* they were substances, but are by no means substances in the proper sense—a Platonic opinion that Aristotle opposed (cf. especially *Metaph.* M 2-3). Moreover, space had no role in Aristotle's ontology, and spatial notions such as 'place' (τόπος) had for him no connection whatsoever with mathematics. Thomasius asked Leibniz to defend his interpretation by showing Aristotelian texts that could back it, in his letter of 2/12 October 1668, in A II, 1, N. 10, 19–20.

[50] The main passage is in Leibniz's letter to Thomasius of 20/30 April 1669, in A II, 1, N. 11, 30: 'Caeterum figuram esse substantiam, aut potius spatium esse substantiam, figuram esse quiddam substantiale, probaverim quia omnis scientia sit de substantia, Geometria autem quin scientia sit negari non possit.' Leibniz went on by noticing that the *Posterior Analytics* show Aristotle's unwavering commitment to mathematics as the paradigm of science. It is therefore in line with Aristotle's views to claim that space is a substance and geometry is the science of substantial forms. Leibniz was taking sides here on the so-called *quaestio de certitudine mathematicarum*, which had been revived by Alessandro Piccolomini in 1547 and was still debated in the seventeenth century. The main question was whether mathematics was a perfect science for Aristotle, given that the examples in the *Posterior Analytics* are indeed mathematical but the theory of science expounded there (and elsewhere) may cast doubts on the fitness of mathematics to comply with Aristotle's requirements for science. On the topic, see A. De Pace, *Le matematiche e il mondo. Ricerche su un dibattito in Italia nella seconda metà del Cinquecento* (Milan: Franco Angeli, 1993).

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> space it fills, while the nature of matter itself is to be dense and impenetrable . . . .
>
> Space is the first extended thing, that is, the mathematical body, which does not consist of anything but three dimensions and is the universal place of all things. Matter is the second extended thing, that is, a thing that besides extension and a mathematical body also has a physical body, that is, resistance, ἀντιτυπία, density, space-filling capacity, impenetrability . . . .
>
> To be extended, indeed, is nothing but to be in space; ἀντιτυπία is the impossibility of being in the same space with something else. From this it is clear that the nature of body is constituted by extension and antitypy.[51]

Here, Leibniz was openly endorsing the Neoplatonic ontology of space of the most radical *novatores*. He was accepting many of the theses that we have seen defended by Patrizi or Campanella (both mentioned by Leibniz in his correspondence with Thomasius), such as that space is more substantial than bodies, that geometry is the science of space, and that the essence of matter is impenetrability and it acquires extension by being in space.[52] The pseudo-Aristotelian argument that space is a substance since geometry is the science of space seems, by contrast, to be of Leibniz's own making.

It is of great importance to recognize these Neoplatonic sources of Leibniz's early thinking. They have been largely neglected by current literature, which has rather pointed fingers towards very general Platonic sources,[53] modern atomism,[54] or reformed Averroism.[55] Without disregarding the importance

[51] A II, 1, N. 11, 26–7, 34, 36. We have seen the expression 'first extended thing' referring to space in Leibniz's early notes on Stahl (see above, note 43).

[52] Patrizi and Campanella are quoted in Leibniz's letter to Thomasius of 20/30 April 1669; A II, 1, N. 11, 24; Campanella is mentioned again there at 35, and in several other texts from the same years; Patrizi in the *De arte combinatoria* (A VI, 1, N. 8, 191; Mugnai, van Ruler, and Wilson, *Combinatorial Art*, 145).

[53] C. Mercer, *Leibniz's Metaphysics: Its Origins and Development* (Cambridge: Cambridge University Press, 2001), for instance, investigating the metaphysical views of the young Leibniz, connected them in detail with the Platonic and Neoplatonic tradition, but Leibniz's views on space and their relation with Patrizi and other Italian Neoplatonists are never mentioned.

[54] Since Leibniz had flirted with atomism in his early years, commentators connected his early positions on space to modern atomism. Modern atomists such as Gassendi, however, were themselves drawing from Patrizi (and explicitly so) concerning the independence of space from matter. Leibniz's stances in the correspondence with Thomasius, in any case, are closer to the original Patrizi than to Gassendi's inherited conceptions of space. Leibniz's statements that space is 'more than substantial', that matter acquires extension by unfolding in space, that space is the source of quantity, and that geometry is the science of space are *not* Gassendi's, and not common to other atomistic authors either. The reference to ἀντιτυπία, although originally Democritean, had already been widely employed by ancient (Plotinus) and modern (Patrizi) Neoplatonists.

[55] Since Averroists generally claimed that prime matter is extended and quantified, few interpreters have read the Leibniz–Thomasius correspondence as a declaration of Averroism

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of these further influences, I would claim that the radical views of the late-Renaissance Neoplatonists were even more fundamental for Leibniz's metaphysics and natural philosophy in the 1660s.

A reappraisal of Leibniz's early sources also allows us to better understand and explain his later philosophy.

In the first place, Leibniz's early engagement with Neoplatonic theories of space cannot be dismissed as an inconsequential episode of his intellectual development. While in later years Leibniz came to reject the substantiality of space, he continued to endorse—although in a transfigured way—the other main tenets of the Neoplatonic tradition: matter is *per se* impenetrable; it is only extended insofar as it is in space; and geometry is the science of space.[56] These ideas, which shaped Leibniz's thought in his youth, had a lasting influence on his philosophy.

Second, the acknowledgement of Leibniz's Neoplatonic sources allows for a tighter comparison with Newton's views on space.[57]

I would not hasten to straightforwardly equate these early Leibnizian conceptions with Newton's own views in the *De gravitatione* or elsewhere. There are important peculiarities in both accounts, as well as differences in the sources specific to the two authors. For instance, the spatial metaphysics of Henry More is generally regarded as an important influence on Newton, while it was immaterial for Leibniz.[58] Newton claimed that space was neither

on Leibniz's part. Averroist philosophers are explicitly quoted by Leibniz in the course of the exchange; see Leibniz's letter of 20/30 April 1669: 'quantitatem quoque habet materia, sed interminatam, ut vocant Averroistae' (26). While this may be the case regarding several doctrines, I would insist that Leibniz's theory of quantified matter has no real Averroist ancestors and is integrally grounded in the views of the Italian *novatores* insofar as prime matter is for them (as for Leibniz) essentially unextended and acquires extension in space—something that Averroists had never claimed. For a reading of the correspondence stressing Averroistic influences, see Laerke, 'Averroism'.

[56] For the evolution of these views, see notes 18 and 86 and the paragraphs to which they are appended.

[57] A word of caution is in order here. Newton scholars still strongly debate the extent to which Newton endorsed a Neoplatonic metaphysics of space in *De gravitatione* and later at the time of *Principia*. I am inclined to think that he did very much (even if with some qualifications) but will not argue for this thesis here. The topic of the present essay is Leibniz's theory of space and Leibniz's understanding of Newton's theory of space; and there is no doubt that Leibniz *did* read Newton's *Principia* as expounding a Neoplatonic theory of space similar to that of Henry More. Cf. note 58 below, as well as the quote in note 36 above. On the evolution of Newton's conceptions of space, see the important A. Janiak, *Newton as Philosopher* (Cambridge: Cambridge University Press, 2008).

[58] In the dense forest of 1146 authors, whose works Leibniz explicitly cited between 1663 and 1672, More does not appear at all (cf. A VI, 2, 659–713). More endorsed a few opinions that Leibniz might have liked in different moments of his life, such as the composition of matter out of indivisible monads and the need for entelechies to bring cohesion in this matter. Leibniz,

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substance nor accident, whereas Leibniz was more inclined towards representing it as a substance in the proper sense. Moreover, Leibniz's early defense of the substantiality (or supersubstantiality) of space had no theological implications whatsoever, and there are no passages from the 1660s and early 1670s in which Leibniz equated space with God, the immensity of God, or an emanative effect of God. This was, however, done by Newton and his sources.

But it is fair to say that in his early years Leibniz was largely working in the same philosophical tradition that inspired Newton's metaphysical thoughts on space, and that both men were fighting against the same enemies: orthodox and unorthodox Aristotelian Scholasticism on place and space as imaginary or negative beings; and Descartes's purely conceptual distinction between space and matter.[59] They both recognized the inability of the traditional theories of space to ground modern philosophy and science, and were looking—in the same direction—for something new.

This agreement between Leibniz and Newton on the nature of space was short-lived. As early as 1672, Leibniz abandoned the Neoplatonic metaphysics of space, and his views on the subject began to diverge more and more from those that Newton was developing in the same years.[60]

Leibniz's dissatisfaction with the substantivalist theory of space was a by-product of his evolving views on the nature of matter. Leibniz played out this important transformation of his natural philosophy in three moves.

(1) A few months after penning his letters to Thomasius, Leibniz embarked on a new project in natural philosophy that resulted in the publication of the important *Hypothesis physica nova* in 1671. This work remained silent on the nature of space, but from Leibniz's drafts of 1669–70 it is clear that he still considered space as a three-dimensional container and motion

however, always opposed More's views on the spatiality of spirits. More is quickly disposed of in §48 of the Fifth Letter to Clarke in reference to his 'plaisantes imaginations' (Robinet, *Leibniz–Clarke*, 146).

[59] Knowing Thomasius's strong aversion to Descartes (see above, note 46), Leibniz assured his former teacher that he was 'anything but a Cartesian' (to Thomasius, 20/30 April 1669; A II, 1, N. 11, 25). Newton famously dedicated a large part of the *De gravitatione* to refuting Descartes's views on space.

[60] Newton's *De gravitatione* may indeed date from 1671. For a review of the main scholarly positions on its composition, see J. A. Ruffner, 'Newton's *De gravitatione*: a review and reassessment', *Archive for History of Exact Sciences*, 66 (2012), 241–64. For a recent argument in favor of 1671, see D. Levitin, 'Isaac Newton's "De gravitatione et aequipondio fluidorum": its purpose in historical context', *Annals of Science*, 78 (2021), 133–61.

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as a change of position in space.[61] As a consequence, the *Hypothesis* tacitly presupposed a kind of absolute motion in absolute space.[62] For instance, Leibniz claimed to have *proven* the truth of the Copernican hypothesis and, as a consequence, the absolute motion of the Earth in space.[63]

The *Hypothesis*, however, was at odds with Leibniz's previous views concerning the nature of antitypy. Leibniz rejected what he now called 'Gassendi's' view (i.e. his own older view) that there is a primitive resistance in matter (antitypy) and claimed that resistance to penetration arises from motion. Bodies are constituted by a multitude of particles that are actually small vortices of matter resisting penetration in proportion to their rotational speed.[64] Bodies do not offer any resistance in themselves: *omnia corpora sunt simpliciter mollissima*.[65] Accordingly, the definition of body is *to be in space* rather than *to resist penetration*:

> The definition of body is: what is in space (or, what is coextended with space). This definition does not contain anything but space and the in-existence.[66]

[61] In the drafts of the *Hypothesis*, Leibniz offers a definition of space as 'a quantum taken with the position of the parts which exist simultaneously' (A VI, 2, N. 38_3, 167). The definition is classical, and Aristotle had defined geometrical magnitudes as quanta taken with the position of their parts. In these fragments, Leibniz's definition of motion is: 'Motus est mutatio spatii' (ibid.).

[62] Leibniz's physics in the *Hypothesis physica nova* is detailed in Garber, *Leibniz*. Garber has convincingly shown that Leibniz's physics in this work was largely inspired by Hobbes's natural philosophy. The underlying conception of space may be an important exception, and it is likely that Leibniz was still endorsing his earlier Neoplatonic views on this topic throughout 1669–71. It is true, however, that in these texts on natural philosophy we do not find explicit statements on the substantiality of space, and some of Leibniz's claims are *also* compatible with Hobbes's distinctive (and non-substantialist) theory of space. It is possible that Leibniz was wavering on this matter and refrained from definite claims. I thank Hao Dong for pointing this out to me.

[63] Leibniz to Oldenburg, 15/25 October 1671, in A II, 1, N. 86, 271 ('Ausim me primum asserere, qui demonstravit Motum Terrae'); Leibniz to Arnauld, beginning November 1671, in A II, 1, N. 87, 278.

[64] For instance: '. . . resistentia omnis est motus, ea igitur tantum dura sunt, quorum partes superficiales ita forti motu moventur, ut extrinseci impellentis impetum retundant. Haec propositio est contra sectatores Democriti et Epicuri, et inter eos egregium Gassendum, a quibus supponitur esse quaedam corpuscula (ipsi atomos vocant) ita solida, ut etiam cum quiescunt, impactu cujuscunque alterius corporis, non dissolvantur' (A VI, 2, N. 38_1, 161). Later, in the Paris years, Leibniz reproached Gassendi again for having conceived of antitypy as a purely negative property (the negation of penetrability), whereas it is necessary to characterize it positively—through motion (A VI, 3, N. 10, 158).

[65] A VI, 2, N. 38_1, 162.

[66] A VI, 2, N. 38_3, 167–8. Inversely, Leibniz sometimes defined space as the possibility of bodies: 'Spatium idem esse quod corporum possibilitatem' (A VI, 2, N. 45_2, 307).

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